Pioneers Of Radio

The worlds of electric and electronic communications owe much to pioneering researchers and inventors. Among them are Thomas A. Edison, Heinrich Hertz and Sir Oliver Lodge.

THOMAS ALVA EDISON

FRED SHUNAMAN

ONE EVENING IN NOVEMBER, 1875, THOMAS Edison, working alone in his laboratory, discovered what he believed to be "an entirely new force." Working with a magnetic vibrator, which included an iron-core coil and an interrupter similar to an old-fashioned doorbell, he noted that sparks jumped from the iron core to any metal body brought close to it. A wire connected to any metal part of the vibrator carried this new force and sparks appeared if the wire was touched to any large metal object. Even if the wire was turned back on itself and formed into a ring, and the end of the wire touched any part of the ring, a spark occurred, which was contrary to any of the then-known laws of electricity. "This," said Edison, "is simply wonderful and a good proof that we are dealing with a not-now-known force."

Further tests confirmed his opinion—the new force did not affect an electroscope or galvanometer, and would not attract small bits of dry cotton wool.

However, Professor Edwin Houston of Philadelphia, who had conducted somewhat similar experiments in 1871, disagreed. He and his colleague, Elihu Thomson, repeated the earlier experiments (see **Radio-Electronics,** December 1975, page 26), and showed that the effects were due to "induced currents" and that the reason Edison could not detect them with (direct-current) instruments was that each current was immediately followed by an "inverse current" that neutralized it.

Edison must have been convinced, for in 1885 he applied for a patent on a "Means of Transmitting Signals Electrically." The patent drawings showed a coil with a low-voltage primary and a rotary circuit breaker to interrupt the primary current. One end of the high-voltage secondary was grounded, the other was attached to a condensing surface suspended as high as possible. One patent drawing depicts this condensing as a wide metal-foil ribbon between the two masts of a ship.

Edison put this invention into use with a "grasshopper telegraph" for communication from a moving train. A foil-covered board on a car roof was the mobile antenna—the telegraph wires served as the trackside antenna. (The system was a success but abandoned after a few weeks because of lack of business.)

The short distance covered by this only practical application of his invention may be one of the reasons Edison's radio was brushed off as an "induction device." The other—and more important—reason is a matter of language. In 1885 (the year after the transformer was invented) induction meant *electrostatic induction* unless otherwise specified. Today it means *magnetic induction*, and modern electronics historians read it as such in the old accounts. Yet before electric waves were known, any electric action at a distance was attributed to electrostatic induction.

Both in the language Edison used and in the distances he expected to cover, it was quite clear that he was not speaking of magnetic induction. He said:

"If sufficient elevation can be obtained to overcome the curvature of the Earth . . . signalling may be carried on by static induction without wires . . ." (obviously beyond the visual horizon). And in explaining his grasshopper telegraph, he told a reporter: "This invention uses what is called static electricity."

Heinrich Hertz

THERE ARE MANY ANSWERS TO THE question, "who invented radio?" But the only answer to "who *discovered* radio?" is Heinrich Hertz!

However, not even this great discovery was entirely new. The Irish physicist Fitzgerald had predicted radio waves and, together with Oliver Lodge, had attempted to reproduce them on wires. Von Bezold of Germany had conducted experiments somewhat similar to those Hertz would perform. "Unfortunately," said Hertz, "their researches did not help me—I learned of them subsequently."

Hertz had noted—like others—that electric discharges produced effects on metal objects separated in space from the discharge. He also noted that these cases were always accompanied by a spark. The effects, he said, depended not only on their theoretical possibility, but also on a "special and surprising property of the electrical spark that could not have been foreseen by any theory."

Therefore, in 1887 Hertz began to work with spark discharges, developing what became the familiar spark-coil transmitter. To detect any waves that might be produced, he used what was called a Reis spark micrometer. This device was an incompletely closed wire loop or rectangle, leaving a small opening at the wire ends. The purpose was not simply to try detecting a spark-discharge effect. He had done that before with a Leyden jar. He wanted to discover if the effects repeated consistently—were in fact *waves* following each other at a regular rate.

Any waves, Hertz reasoned, must ". . . act with a much stronger effect on a circuit having the same period of oscillation than upon one with only a slightly different period." Varying the size of his detector loop, he found that indeed the spark was strong at a certain size, and diminished as the loop was made bigger or smaller than the ideal size. Making a graph of this effect, Hertz produced the first "tuning curve."

Next, Hertz attempted to reflect the waves, using a sheet of zinc, 4 meters long and 2 meters wide, fastened to the end wall of his laboratory. The detector showed points between the transmitter and the end of the room where the sparks were bright, others where they were small or invisible. Thus, he was positive he had produced standing waves in space and was able to measure the transmission wavelength. By calculating the frequency, he was able to estimate the velocity of the waves, and discovered they traveled at or

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at exactly 3.0 kHz. Perhaps a miswiring of the slide switch in the particular unit tested accounts for this. The various weighting factors incorporated into the wow-and-flutter measuring section permit an easy interpretation of percentages and eliminate having to "estimate" this parameter for tape decks and turntables, which is usually required when using unweighted wow-and-flutter measuring equipment.

Summary

Our overall product evaluation of the *model LAS-5500* is summarized in Table 1. This instrument is a space and time saver for the audio bench. It also greatly reduces the complexity of tests and measurements made on audio equipment. While its price may seem prohibitive at first, if you total the cost of a wide-range accurate AC VTVM, a good audio generator, an accurate wow-and-flutter meter and a wideband oscilloscope, it will become clear that the *model LAS-5500* represents something of a bargain. **R-E**

TABLE 1
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Leader Instruments Corp.** Model: **LAS-5500**

OVERALL PRODUCT ANALYSIS

Retail price	**$1995**
Price category	**Medium-high**
Price/performance ratio	**Good**
Styling and appearance	**Very good**
Sound quality	**N/A**
Mechanical performance	**Excellent**

Comments: We feel that this multifunction test instrument is most suited to service-bench use and, in the laboratory, for measuring tape-recorder equipment performance. Its sinewave signal source, although accurately calibrated and extremely flat in response, is a bit too high in its harmonic distortion content to be used to measure today's super-hi-fi audio amplifiers, preamplifiers and receivers. Since tape recorder distortions are generally of a higher magnitude, the audio oscillator contained in the *model LAS-5500* will not contribute to the overall distortion readings made of tape equipment under test or alignment.

Of course, it would have been nice if the instrument had some form of distortion-measuring device. Used by itself, the *model LAS-5500* can determine amplifier overload or clipping levels only by observing output waveforms on the screen of the wideband oscilloscope provided. The wow-and-flutter meter section cannot be faulted in any way; it offers an easy way to measure this important tape recorder and turntable parameter. The high-quality precision attenuator is handy to have in any lab or shop and is accurately calibrated. The 8-ohm loads, supplied separately, have only a 50-watt rating, although we found this rating can be exceeded for short periods of time without degrading the accuracy of the load resistors. Here again, if you regularly test high-powered audio equipment, you will need higher-power-rated loads. Perhaps the best feature of the *model LAS-5500* is its compact size and arrangement. These days, with all the sophisticated equipment necessary to properly test audio equipment, it's a pleasure to find a multipurpose instrument that not only replaces several separate test equipment items but occupies less than 18 inches of valuable bench space.

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near the speed of light. With a large prism of asphalt (measuring 5 × 2 × 1.5 feet) he showed also that the electric waves could be refracted like light waves.

With these proofs, the scientific world accepted the idea of electric waves in space.

Hertz's discovery began not only the scientific study of radio, but also attempts to use it to communicate. In India, the physicist Bose read of Hertz's experiments, duplicated them and devised improved apparatus with which he toured Europe and convinced many scientists of the existence of electric waves. And in Italy, just a few-years later, the young Guglielmo Marconi read Hertz's obituary and decided to try to use these waves as a means of communication.

Sir Oliver Lodge

ALTHOUGH SIR OLIVER LODGE IS NOT TOO well known today, he was considered a leader—if not *the* leader—in the wireless field during the 1890's and the early 1900's. The eminent electrical engineer and author, Sylvanus Thompson, for example, attacked Marconi in a letter (*Saturday Review,* London, April 5, 1902) for posing as the inventor of something new. He (Marconi) was, claimed Thompson, merely using "the apparatus of Lodge . . . the original inventor of wireless telegraphy," with a few modifications.

In 1883, the Irish physicist George Fitzgerald surmised at a meeting of the British Association that "Maxwellian" waves might be produced by the oscillatory discharge of a Leyden jar, "if only we had the means of detecting such waves." In 1888, Lodge and two associates set out to produce and detect such electromagnetic waves, using what were later called Lecher wires to detect them. In Lodge's words:

"I found that the waves could not only be produced but also detected, and the wavelength measured, by getting them to go along guiding wires adjusted to the right length for sympathetic resonance. Thus I obtained the phenomenon of nodes and loops, due to the production of stationary waves by reflection at the distant end." In the same year, Lodge learned of Hertz's work in the field, and immediately attempted to transmit waves through free space.

In 1899, he lectured to the Royal Institution on "The Oscillatory Discharge of a Leyden Jar," demonstrating "many of the effects of these waves, both on wires and in free space." He called his detector (a needle point touching an aluminum plate, in circuit with a battery and telephone receiver) a "coherer" because an electric wave caused both the point and plate to cohere, or stick together, thus lowering the resistance and producing a signal in the phones. Shortly thereafter, when Branley announced his metal-filings coherer, Lodge adopted it, believing it more reliable and easy to adjust than his single-point detector.

In 1894, during a lecture in honor of Hertz (who had just died) Lodge demonstrated the detector. He used a mechanical tapper or vibrator to shake the detector filings apart after a signal passed through them. The coherer was thus constantly ready for action. Holding the transmitter key down for a longer or shorter time produced a long or a short signal in the receiver. Using this tapper, Lodge showed how the dots and dashes of the Morse code could be produced with radio equipment.

Lodge felt that Popov, Righi and others may have been influenced by his 1894 lecture. Professor Alexander Muirhead, who was present at the time, certainly was, and Lodge says he "conceived the desire to apply it to practical telegraphy." The result was a successful Lodge-Muirhead venture into commercial wireless.

Sir Oliver was an early proponent of tuning, which he called "syntony," to reduce interference and increase the range of communications. Although both Hertz and Tesla had mentioned the effect of resonance, in 1897 Lodge was able to obtain a patent (British patent 11,875) on syntony. Marconi later bought the patent from the Lodge-Muirhead syndicate, enormously strengthening his competitive position.

Lodge was interested in a wide variety of other subjects, especially psychic phenomena, and spent much of his time in later years pursuing them. He continued to write on radio topics, however, until well into the 1920's. Sir Oliver Lodge died in 1940. **R-E**